



LIFE08 ENV/IT/436

PROJECT ACT

ADAPTING TO CLIMATE CHANGE IN TIME

Time Series Analysis and Current Climate Trends Estimates

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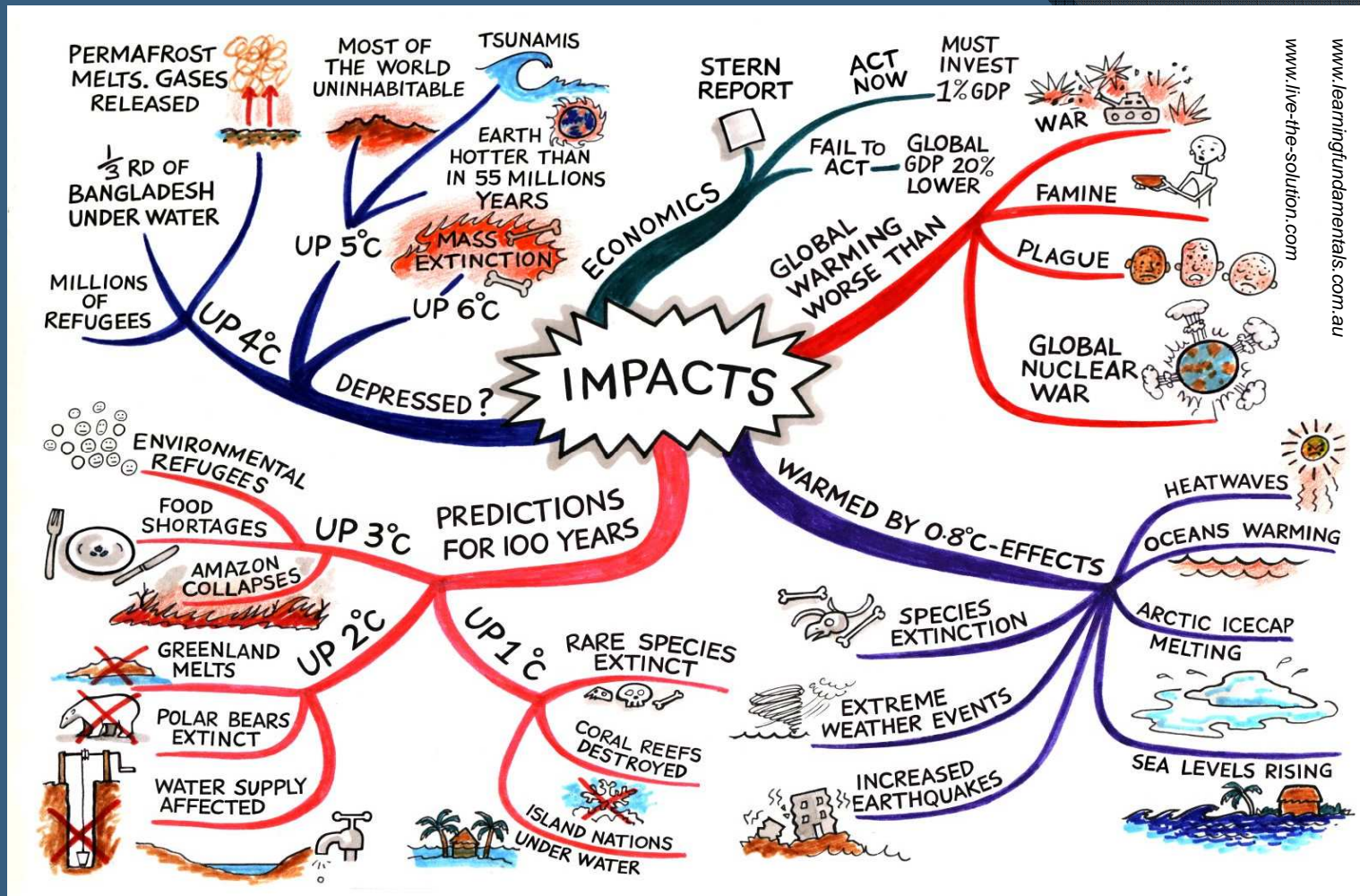
THIS DELIVERY:

1) Introduction: a general overview of time series analysis, with particular attention to homogenisation

2) Results (plots and figures) for Ancona



Climate change **impacts** almost all aspects of human life

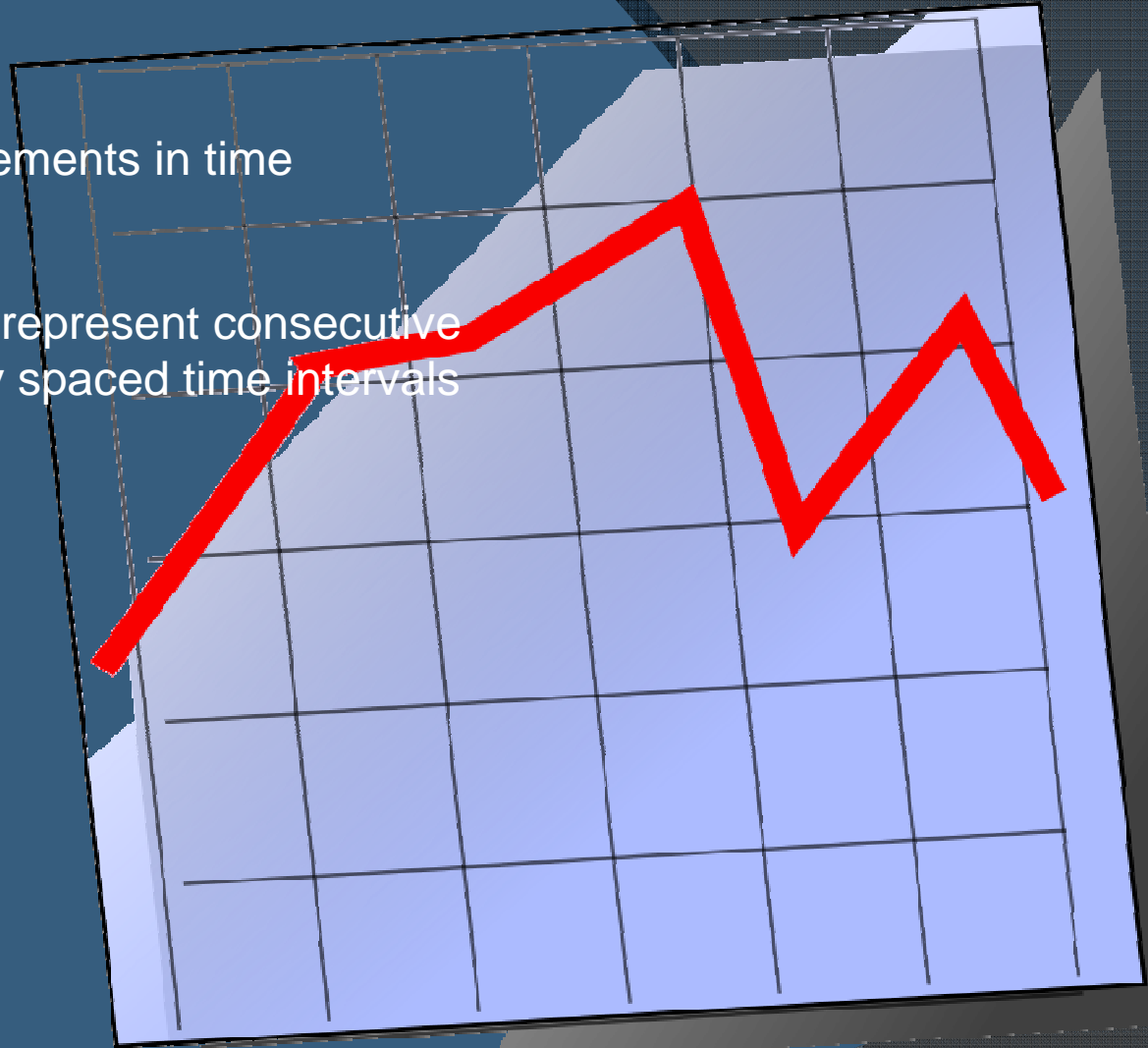


Improvements and extensions of numerous datasets and data analysis, broader geographical coverage, better understanding of uncertainties, and a wider variety of measurement can provide a great deal of information how climate is changing in space and in time

TIME SERIES

Sequences of measurements in time

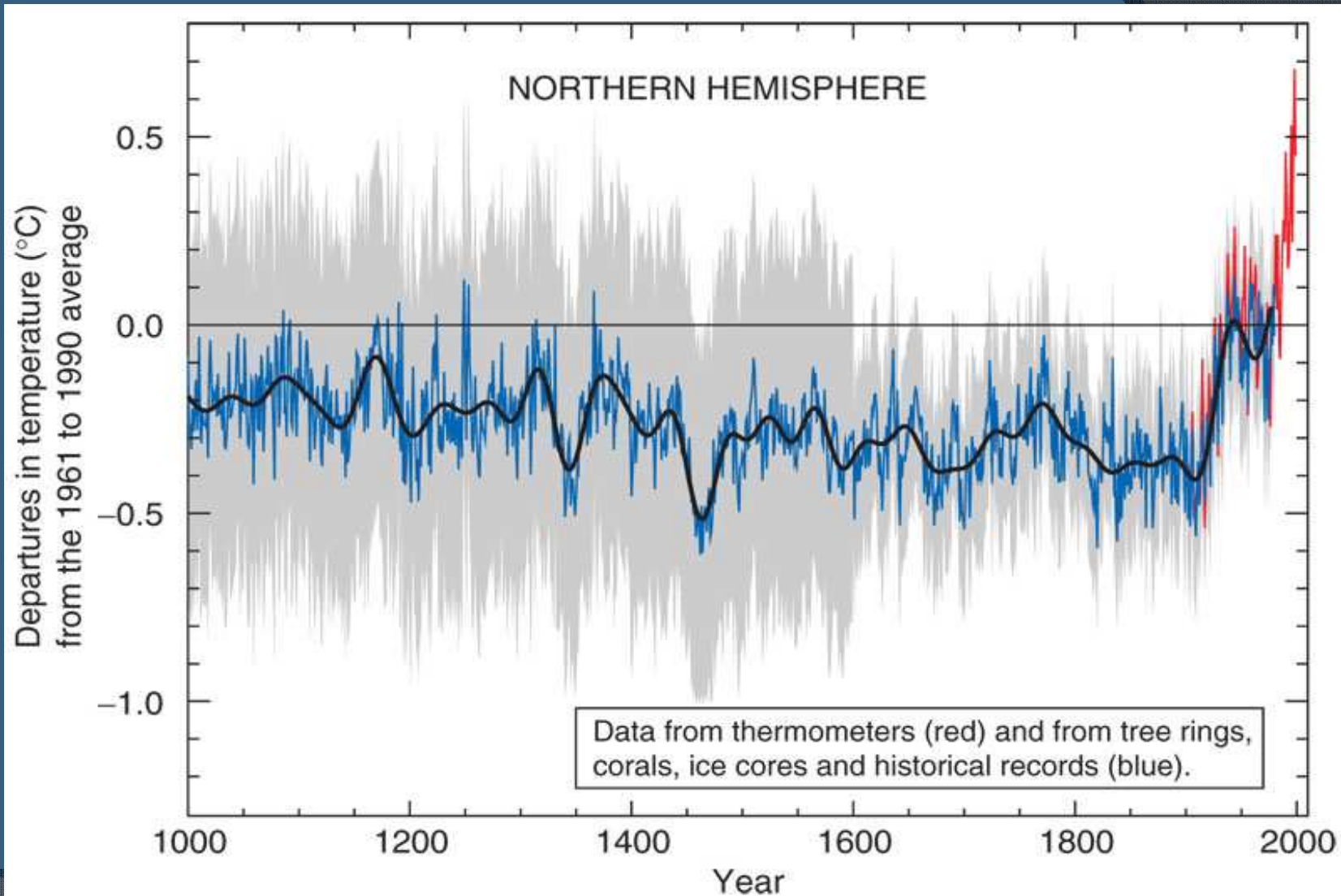
Assumption: successive values represent consecutive measurements taken at equally spaced time intervals



Two main goals

- 1) identifying the nature of the phenomenon represented by the sequence of observations
- 2) forecasting (predicting future values).

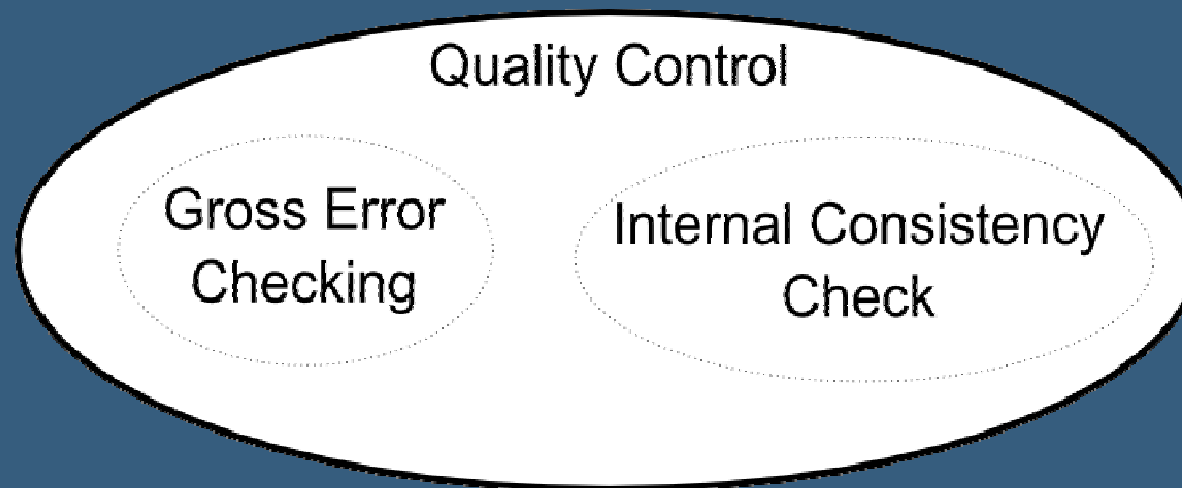
A famous time series: the “hockey stick” graph (Mann et al. 1999)



QUALITY CONTROL of DATA

High quality long-term datasets are needed to assess climate related issues.

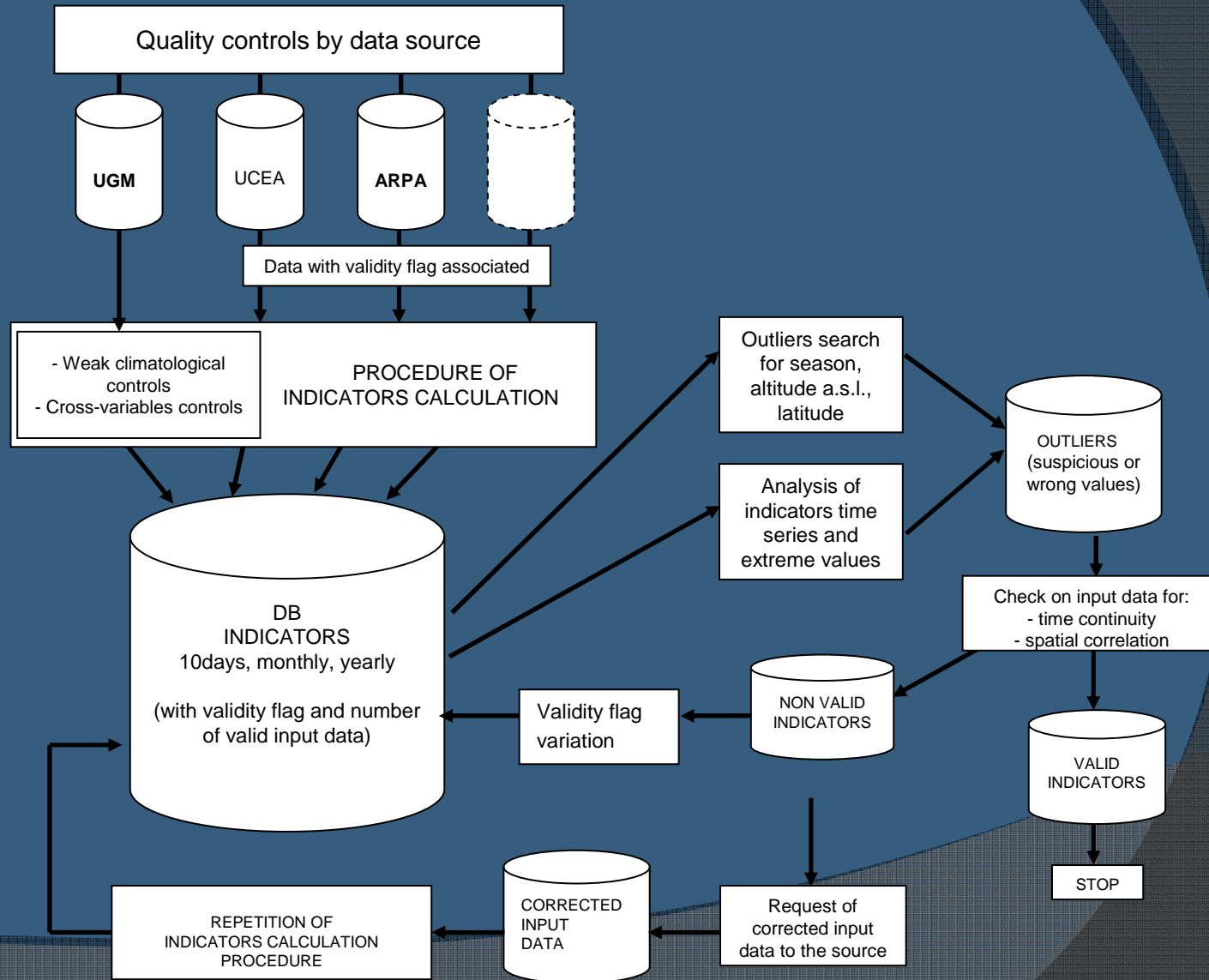
Different procedures are needed to detect and identify the errors made in the process of recording, manipulating, formatting, transmitting and archiving data



1) Gross error checking: to detect and flag obviously erroneous values (e. g., anomalous values, shift in commas, negative precipitation, etc.).

2) Internal consistency check: to inspect coherency between associated elements within each record (e.g., maximum temperature < minimum temperature).

An example: SCIA QUALITY CONTROL



HOMOGENEISATION of TIME SERIES

Long term climate analyses – especially climate change analyses – to be accurate require homogeneous time series

DEFINITION:

A homogeneous climate time series is defined as one where variations are caused only by variations in weather and climate (Conrad and Pollak, 1950).

Unfortunately, most long-term climatological time series have been affected by a number of non-climatic factors that make these data unrepresentative of the actual climate variation occurring over time.

These factors include changes in:

Station locations

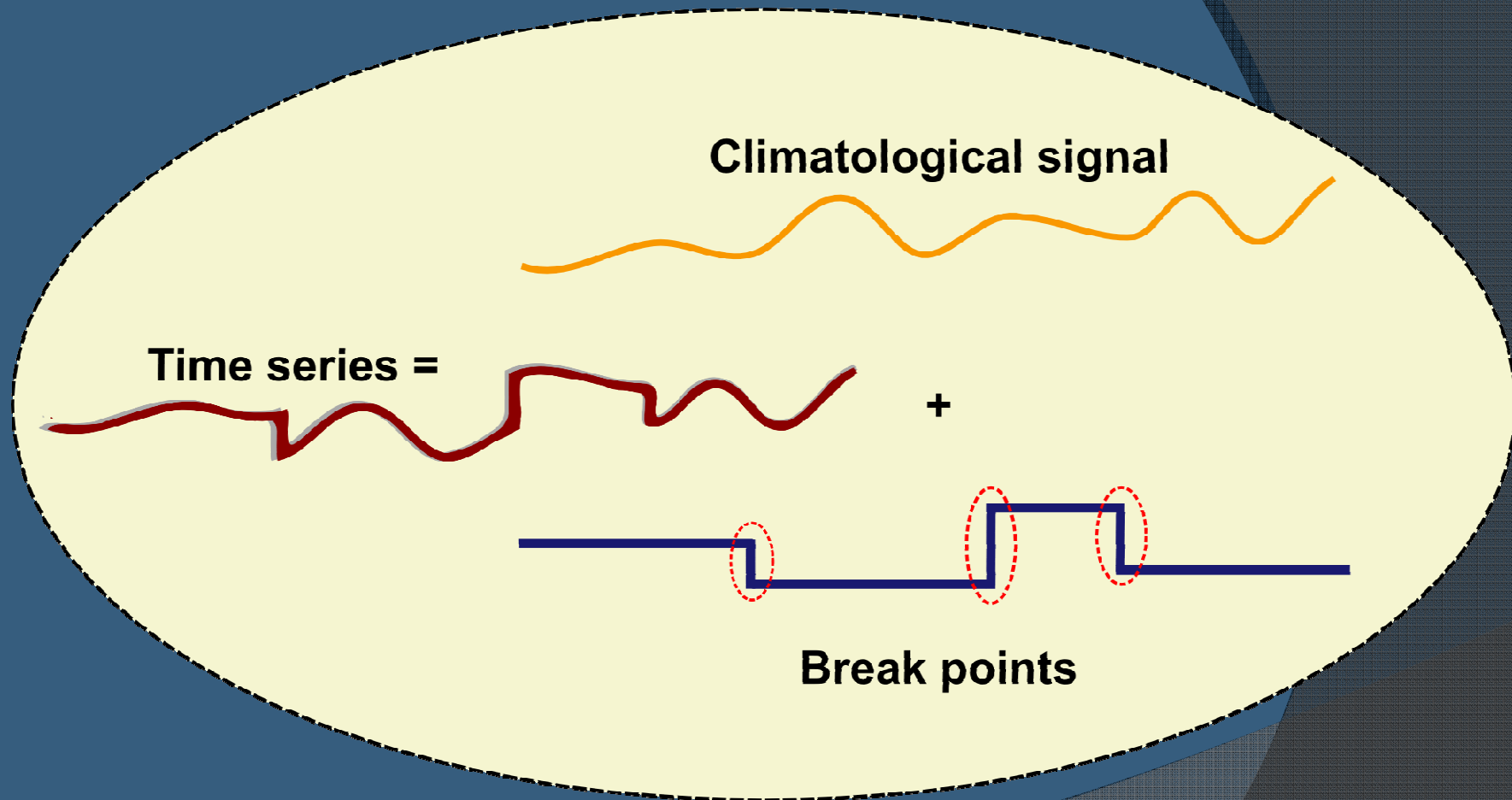
Station environment

Observers

Instruments

Formulae used to calculate means

Some changes cause sharp discontinuities while other changes, particularly change in the environment around the station, can cause gradual biases in the data.



All of these inhomogeneities can bias a time series and lead to misinterpretations of the studied climate. It is important, therefore, to remove the inhomogeneities or at least determine the possible error they may cause.

HOMOGENEISATION OF TIME SERIES: WHY? An example (Meteo France)

Meteorological stations for the long-term series of La Rochelle



1910 primary school

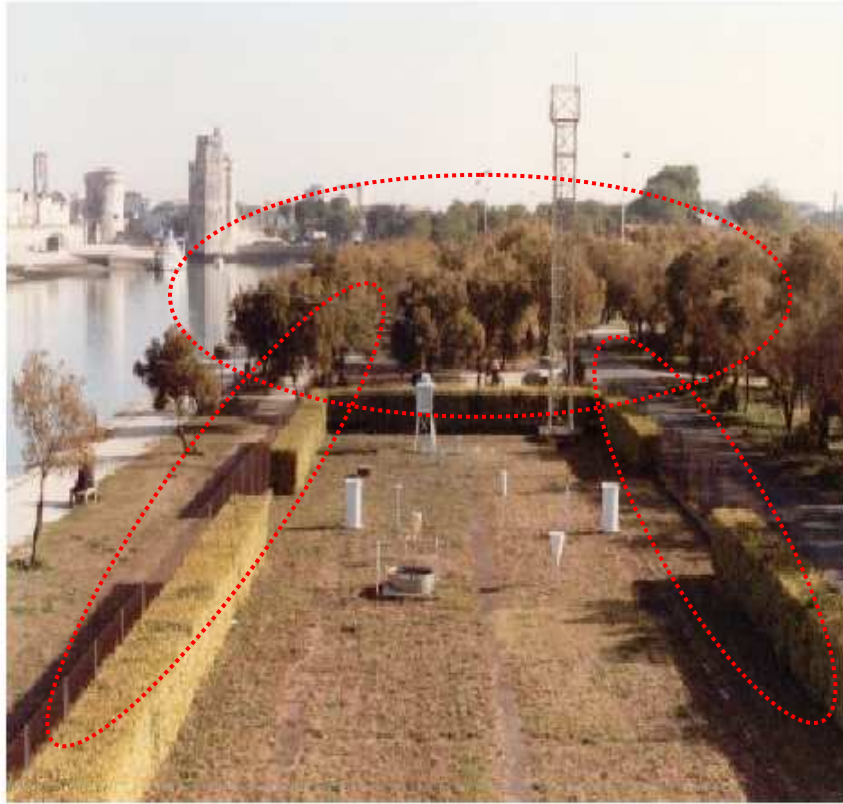


1999 departmental center
Le Bout Blanc

Long ago , conditions of measurement were not fully standardized

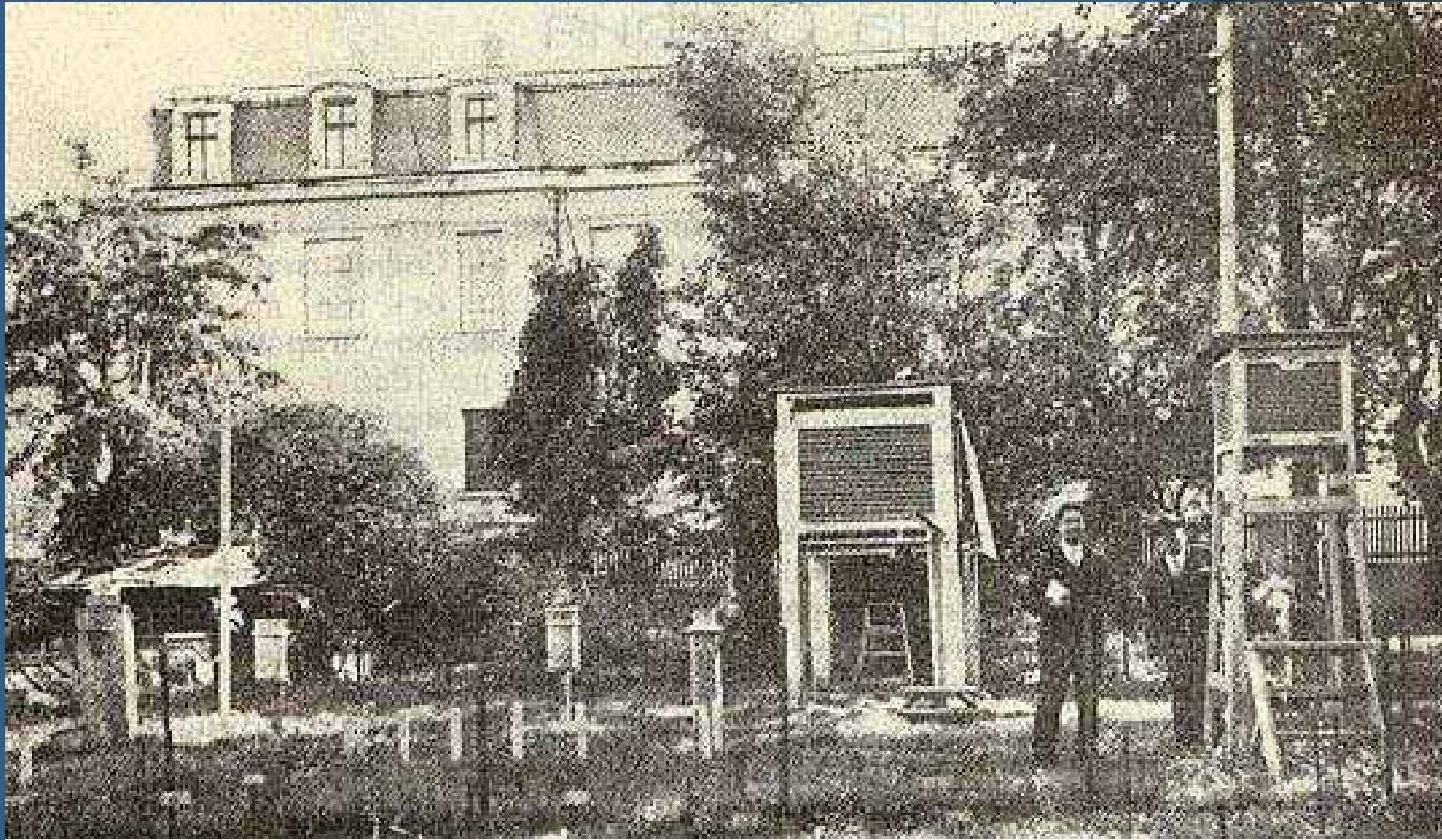
Nowadays conditions of measurement are well defined by WMO

HOMOGENEISATION OF TIME SERIES: WHY? An example (Meteo France)



La Rochelle: Le Bout Blanc in 1995 (left) and 2004 (right)

An example: weather stations in Sofia (National Institute of Meteorology and Hydrology, Sofia)



The first weather station in Sofia (19th century)

An example: weather stations in Sofia (National Institute of Meteorology and Hydrology, Sofia)



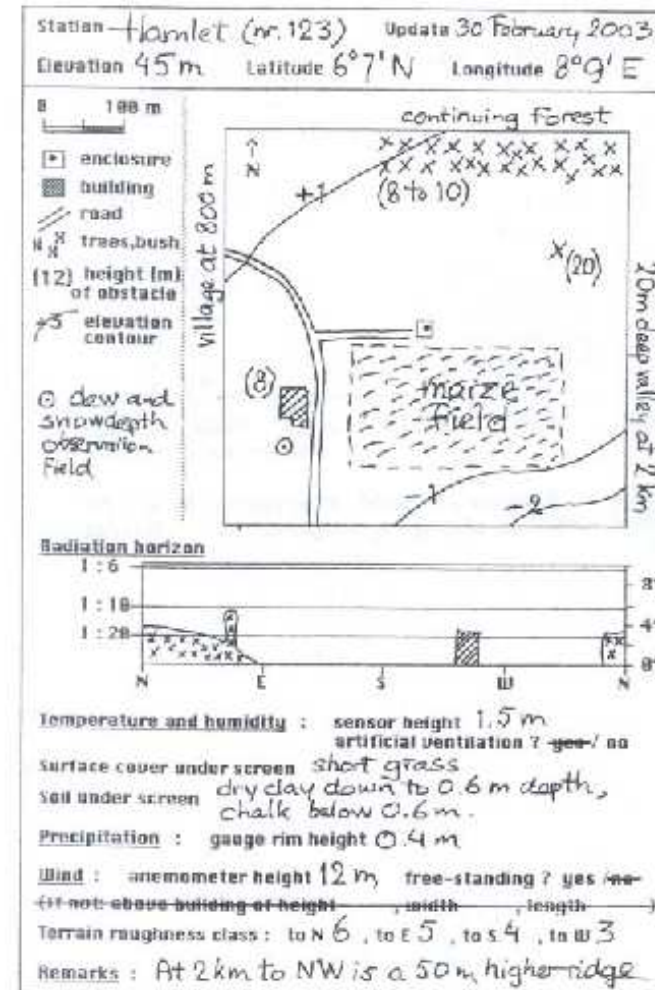
New weather station in Sofia (21st century)

Metadata: relevant information to trace a time series

- location of the observations (name of the site, coordinates ..)
- time period of the observations
- observed variables
- observation frequency
-

Metadata are **essential** to confirm a break or to accurately locate a break

However, **usually** there are more breaks than metadata!



Aguilar *et al.*, 2003

Example of template for documenting metadata at the toposcale ("local" scale, 100m to 2 km)

SEVERAL METHODS HAVE BEEN DEVELOPED TO HOMOGENISE LONG-TERM SERIES (see [COST – ES0601 HOME](#) action)



Many methods relies on the existence of a homogeneous regional reference series (e.g. [Alexandersson - SNHT](#))

Other methods do not rely on the existence of homogeneous reference series : e.g. [Caussinus - Mestre \(CM\)](#)

Homogenisation of time series is not an automatic process. The role of [EXPERTS](#) is essential.

Reference Series

A change in a time series may indicate inhomogeneities or may simply indicate an abrupt change in the regional climate.

To isolate the effects of station discontinuities from regional climate change, many techniques use data from nearby stations as an indicator of the regional climate. Any significant variation from that regional climate signal is assumed to be due to inhomogeneities.

The method used to form the reference time series can be important

Reference series for Ancona



Reference series for Ancona

CODE	NAME	CORR.	LON	LAT	ELEVATION (m)
6810	Pescara	0.845	14.2	42.43	11
6782	Frontone	0.879	12.73	43.52	574
6768	Cervia	0.893	12.3	44.22	10
6769	Rimini	0.908	12.62	44.03	13

RESULTS

Homogenisation and trend estimation of climate time series require:

- Long term series (**at least** 40 years) for the candidate station
- **At least** three reference stations with long term series (**at least** 40 years).

Reference stations must be **representative** of the regional climate of the candidate station.

Ancona: temperature time series

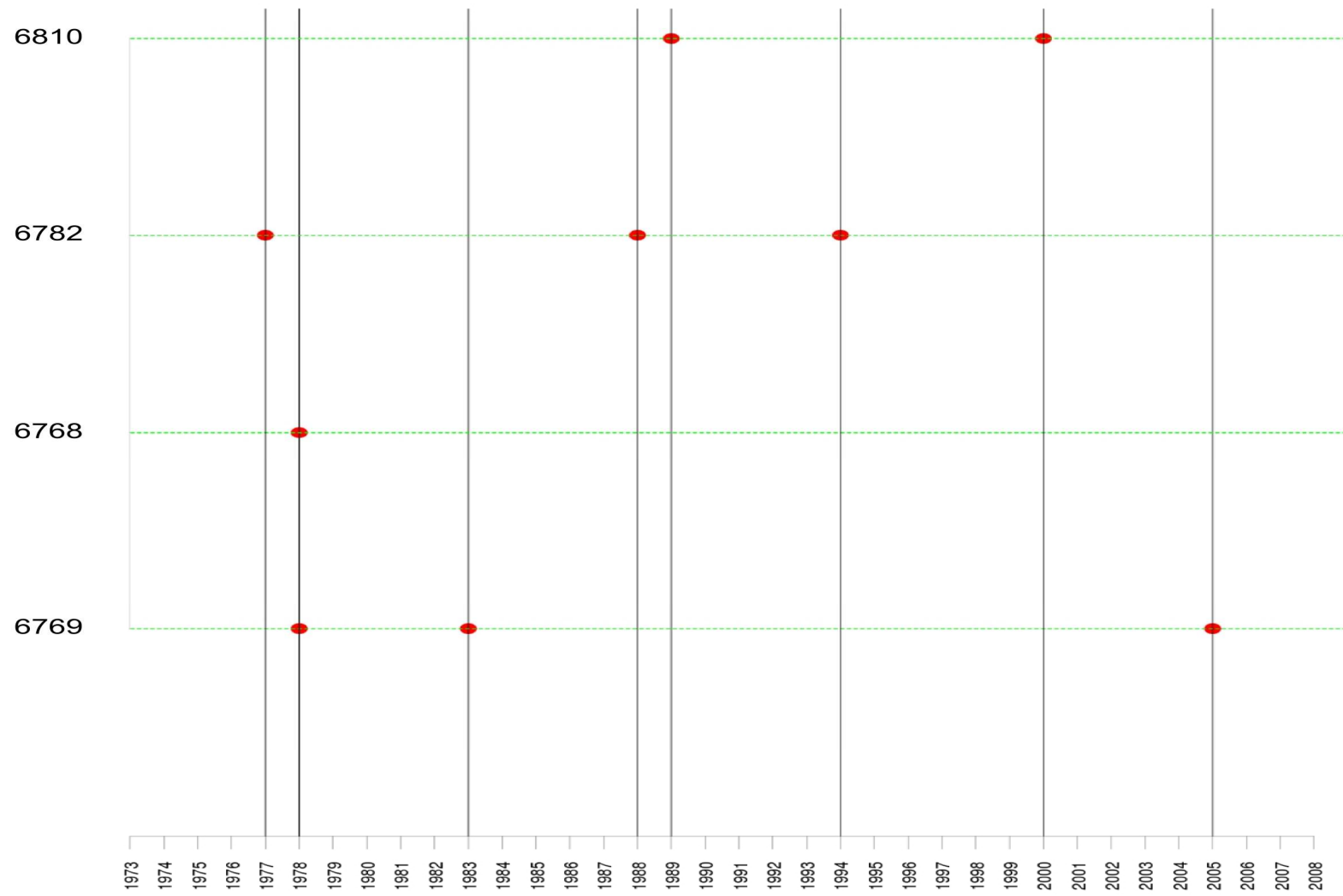
Trend assessment is based on the time series **from 1973 to 2006**

We are going to update such estimations by means of new data now available to us (values from 2007 – 2009).

However, these new data **will not alter** the general meaning of our partial results.

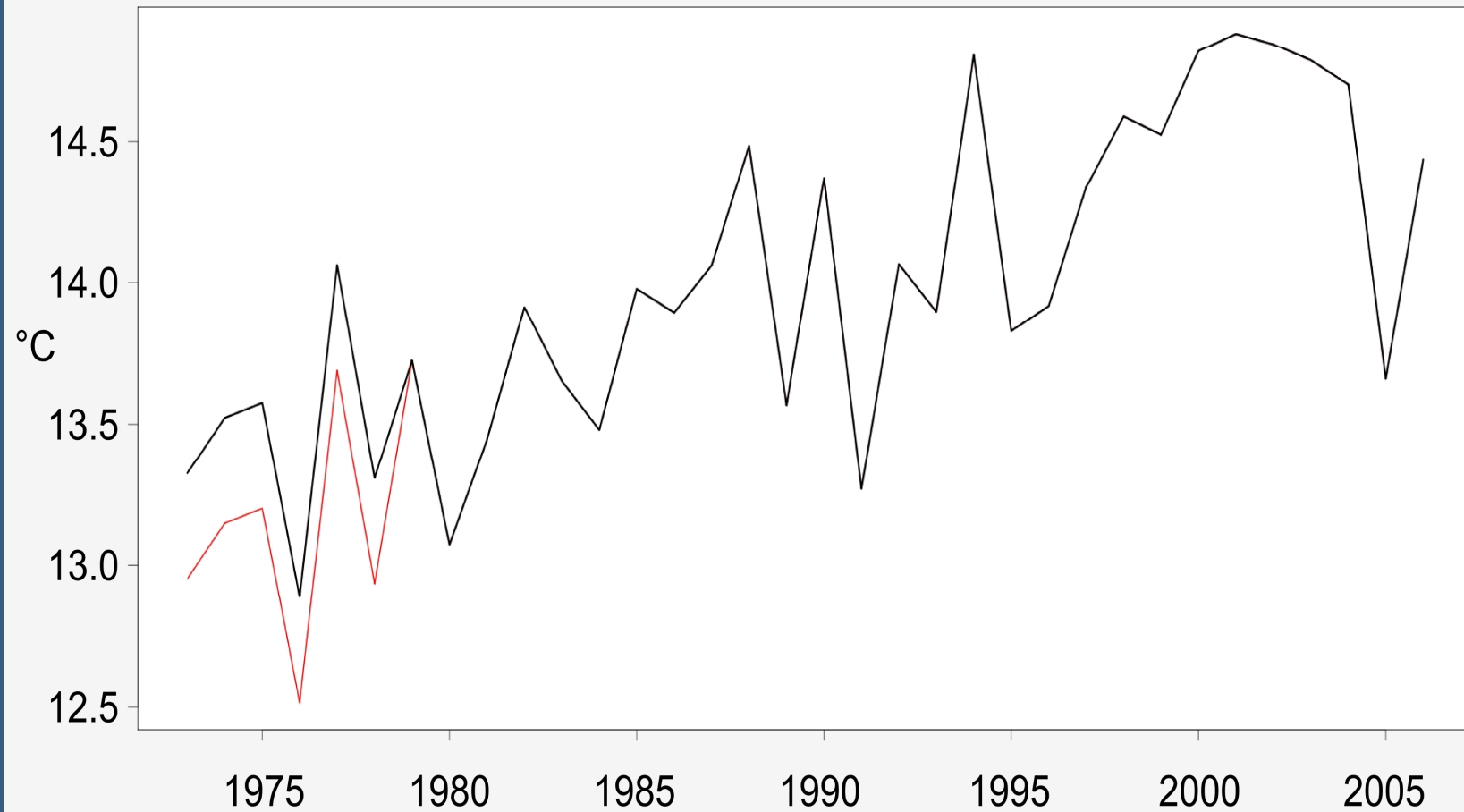
Both tests (**SNHT and CM**) identified a break point in 1978

No metadata about the station history to support the decision for homogenisation

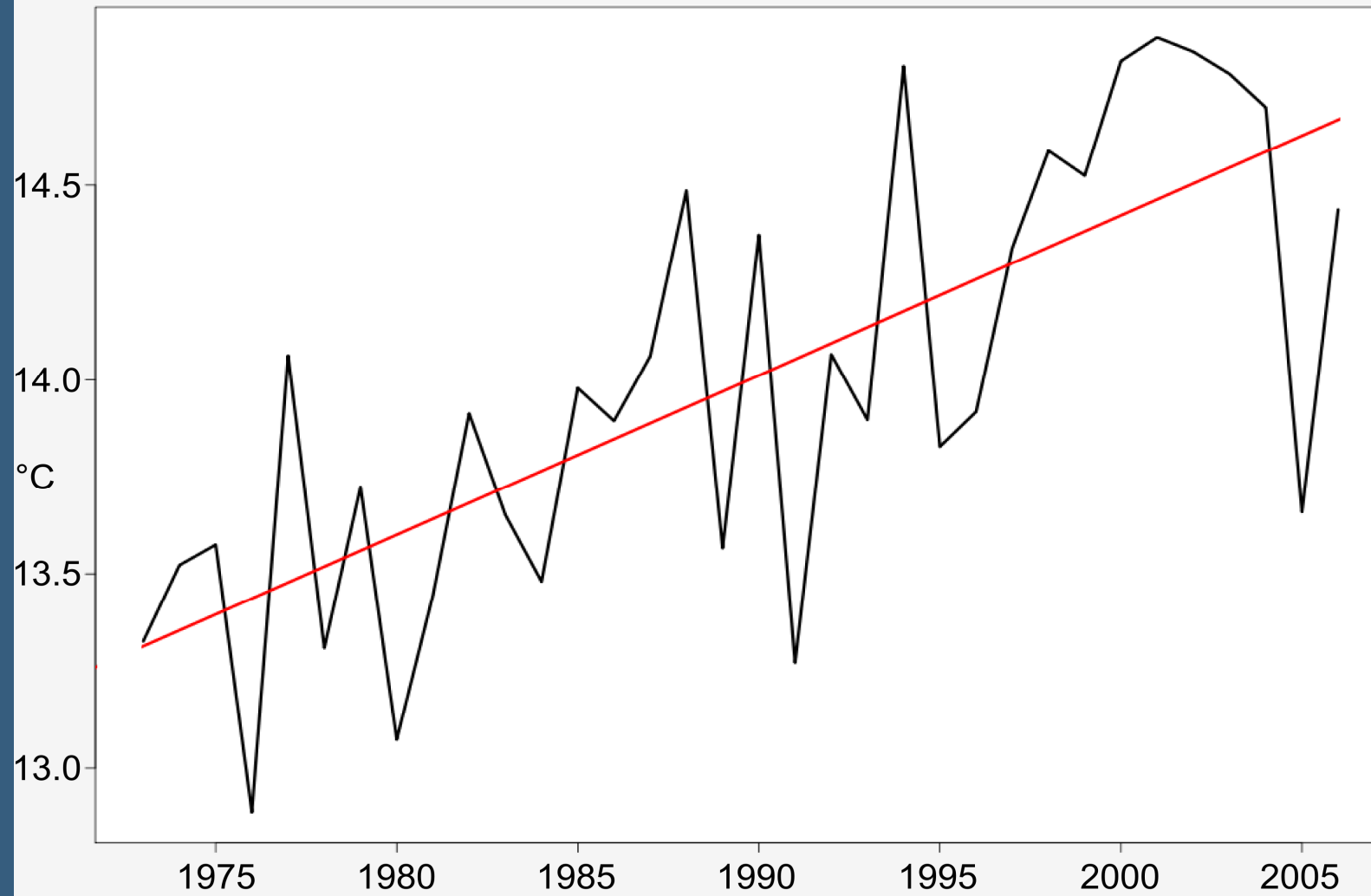


Ancona: annual mean temperature series.

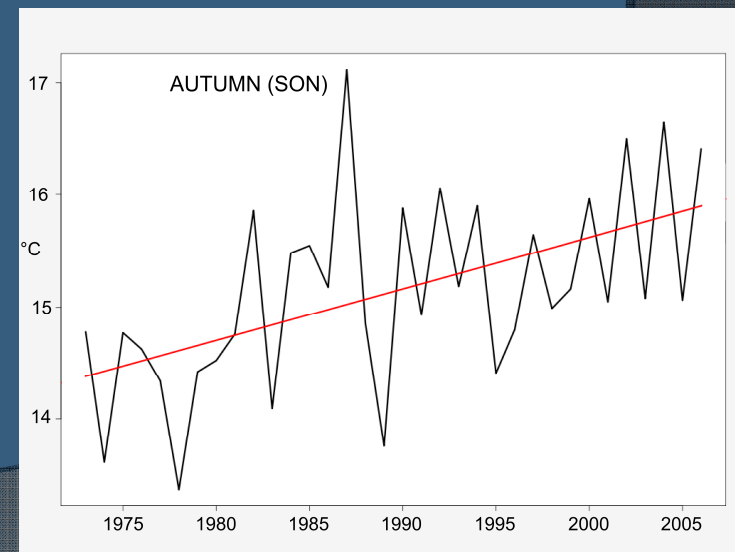
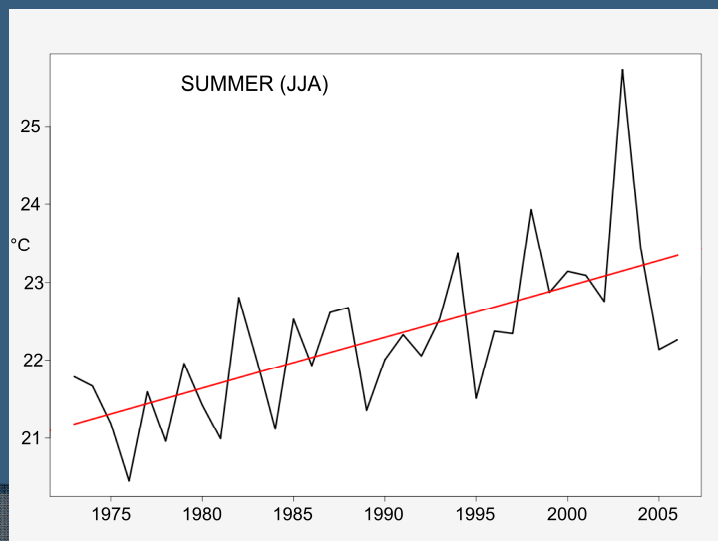
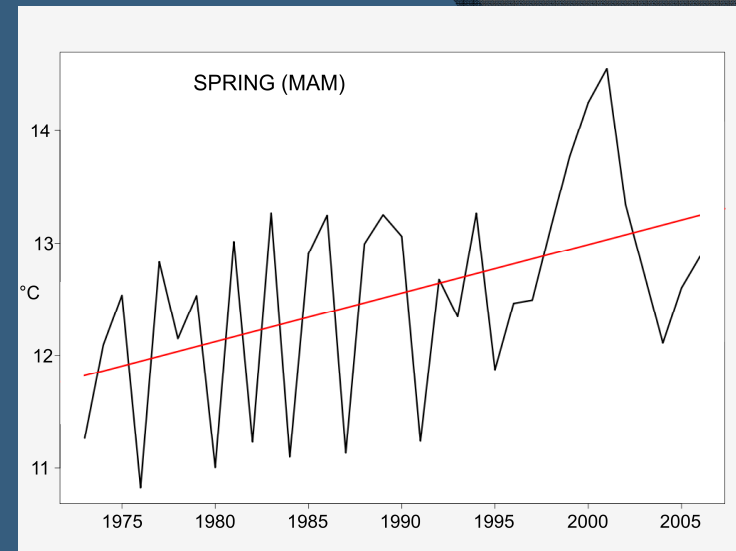
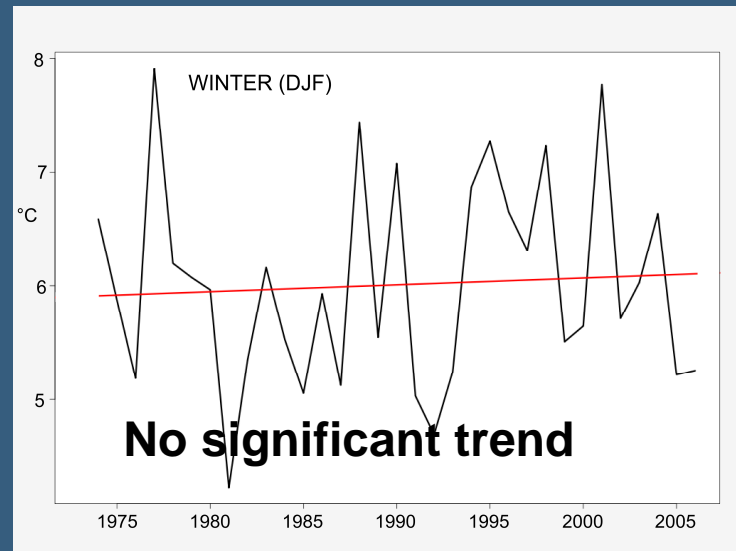
Homogenised (black line) and original (red line)



Ancona: annual mean temperature series.



Ancona: seasonal mean temperature series.



	Annual	Winter	Spring	Summer	Autumn
Slope (°C)	<i>0.041</i>	-	<i>0.043</i>	<i>0.066</i>	<i>0.046</i>
Std. Error	<i>0.0068</i>	-	<i>0.0145</i>	<i>0.0134</i>	<i>0.0131</i>
Temperature increase (°C) (1973 – 2006)	1.39	-	1.46	2.24	1.56

Trend assessment by means of **Mann-Kendal** test (95% significance)

Ancona: precipitation time series

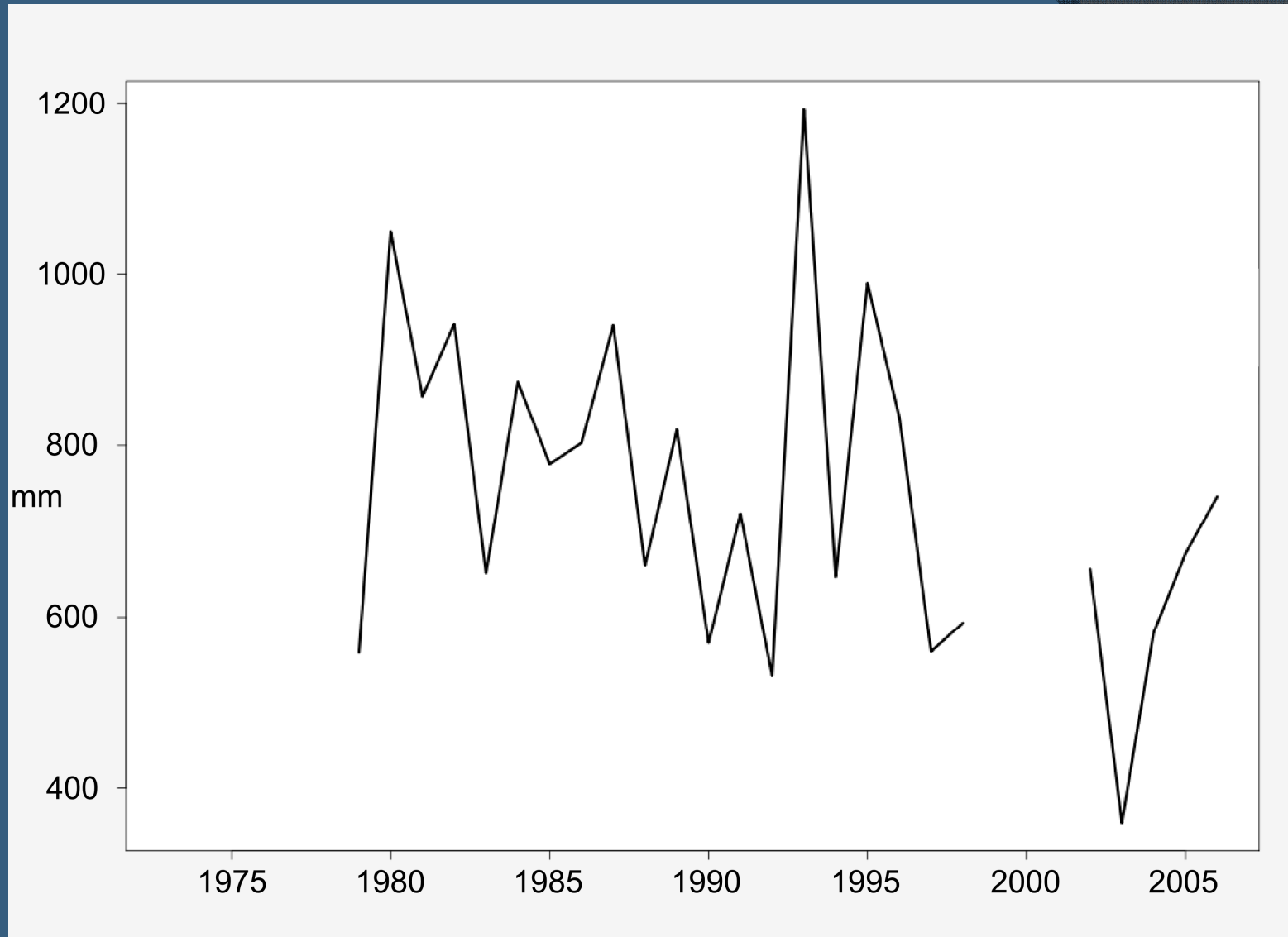
Trends assessment is based on the time series **from 1978/1979 to 2006**

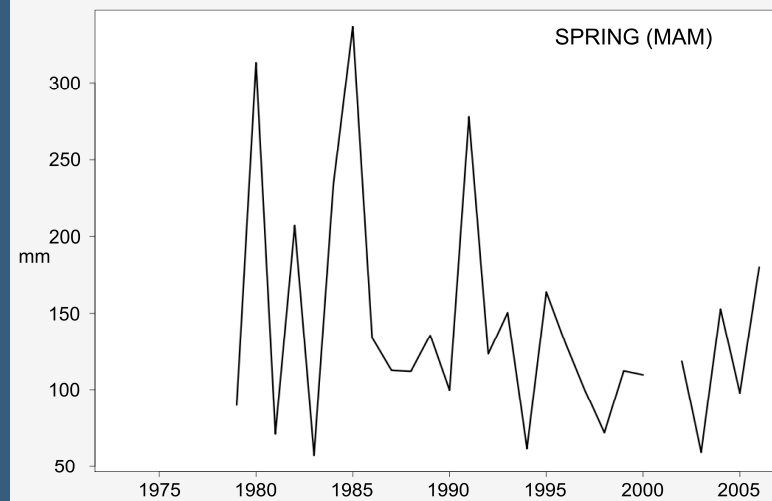
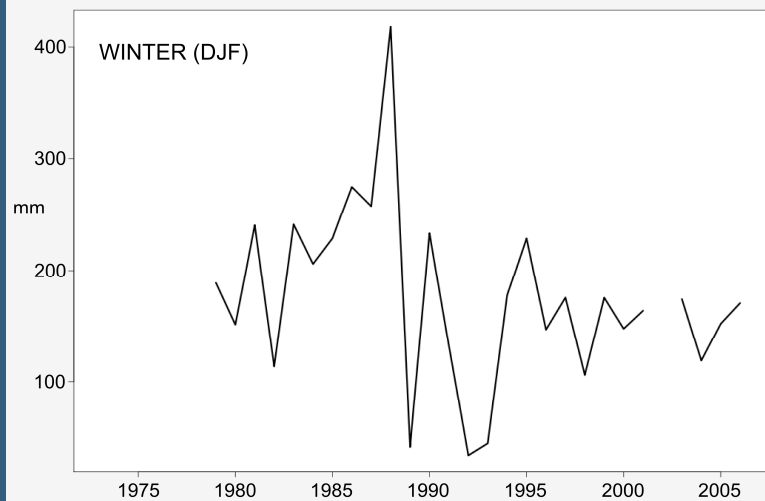
No break point was detected

No significant trend highlighted in spring, summer and autumn

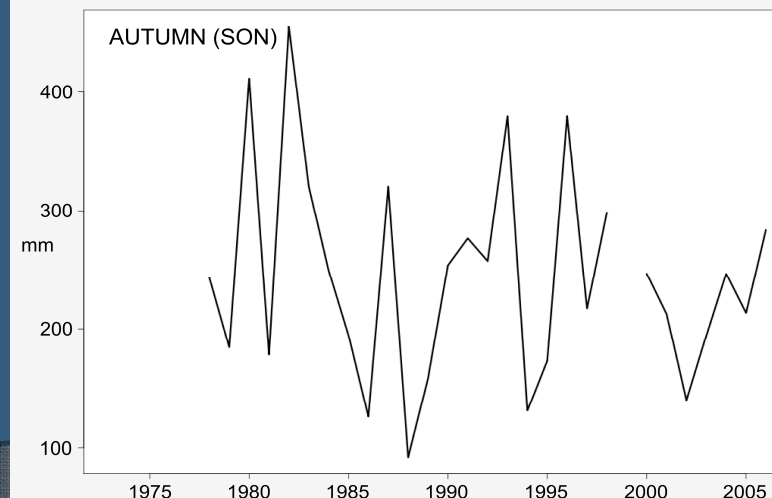
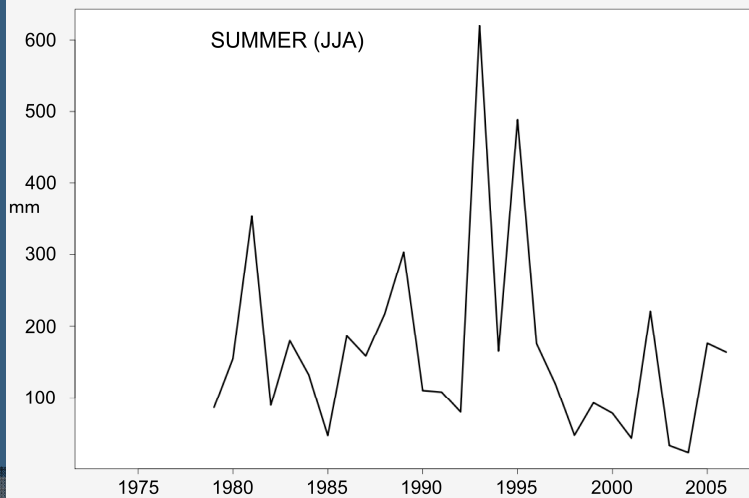
A significant decrease was identified in winter **but** longer series are needed to verify this result.

Ancona: annual precipitation time series





Ancona: seasonal precipitation time series



EXTREME EVENTS

Weather events with values far away from the mean (such as heat waves, droughts and flooding) are by definition less likely to occur.

Nature and society are adapted to the regional weather averaged over longer periods, but much less to extremes.

Small changes in climate may have a large impact on the occurrence of weather events in space and time, and on the intensity of extremes.

Nature and society are often particularly ill prepared and vulnerable for such changes.

Temperature extremes like summer days, tropical nights, and heat waves have become more frequent, while low - temperature extremes (e.g. cold spells, frost days) have become less frequent in Europe (IPCC, 2007a)

Climate change projections suggest that European summer heatwaves will become more frequent and severe during this century.



A combination of extremely high day- and night-time temperatures contribute to enhanced morbidity and mortality (e.g. Summer 2003)

(Fischer and Schaefer, 2010)

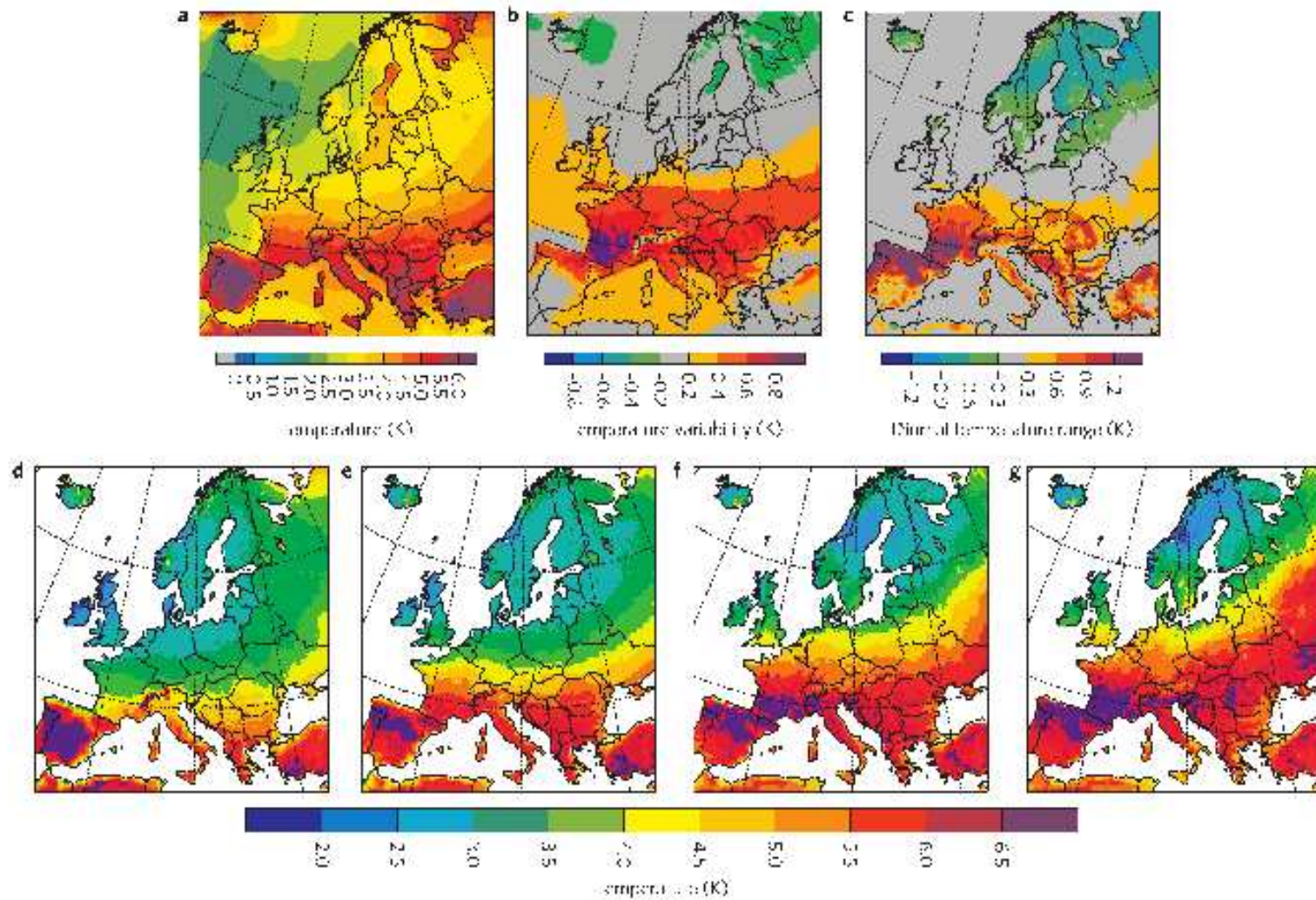


Figure 1 | Climate-change scenarios for daily summer temperature statistics. Projected ensemble mean changes in summer (JJA) for six simulations of the ENSEMBLES project for 2071-2100 with respect to 1961-1990. **a.** Mean temperature. **b.** Daily temperature variability (standard deviations of all summer days). **c.** Diurnal temperature range. **d-g.** The same as in **a.** but for 10th (**d**), 50th (**e**), 95th (**f**) and 99th (**g**) percentiles of daily maximum temperatures.

HEAT WAVES

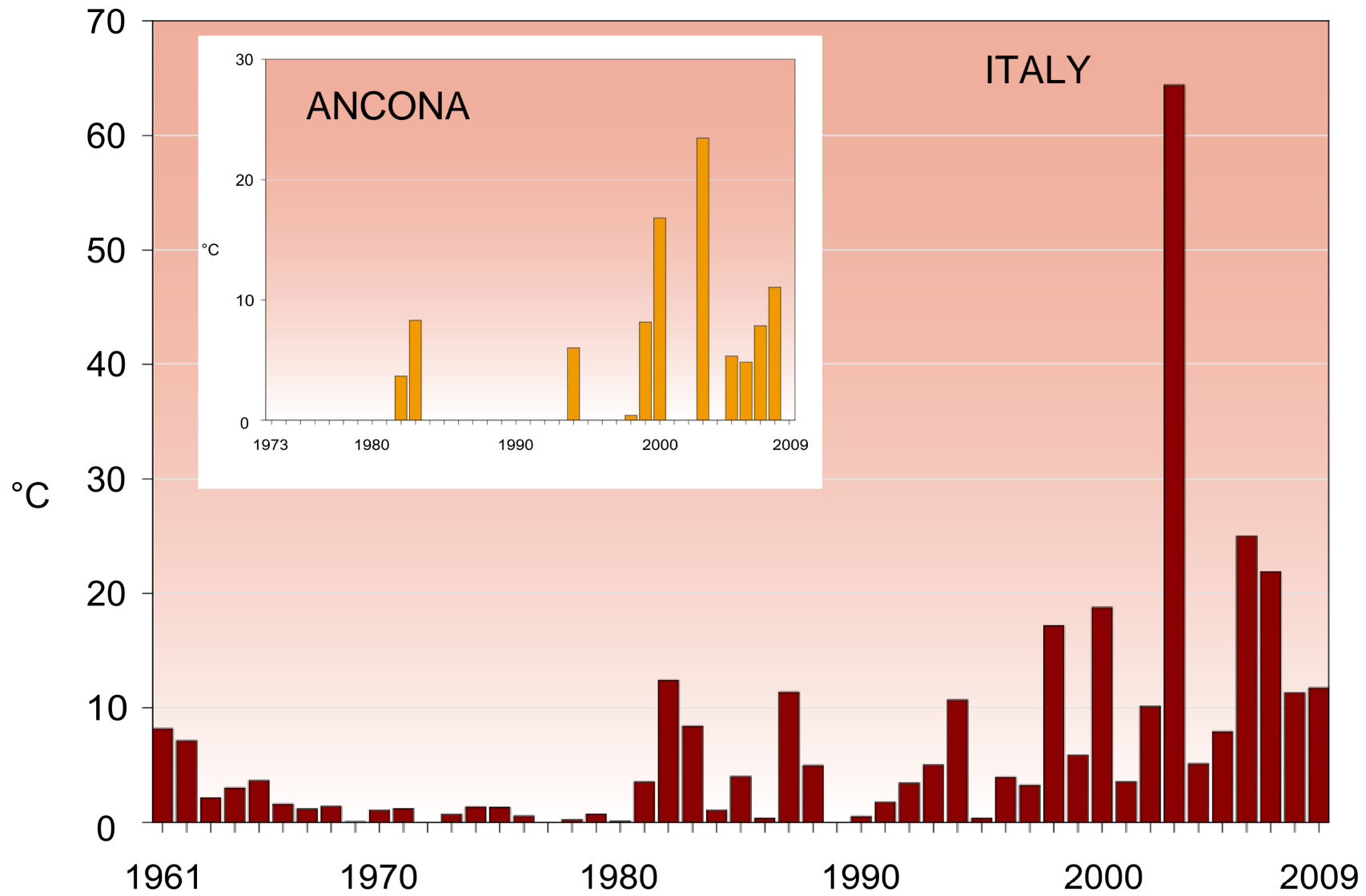
The most severe impacts arise from multi-day **heatwaves**, associated with **warm night-time temperatures** and high relative humidity.

Definition of heat wave: maximum temperature greater than a particular threshold for prolonged days

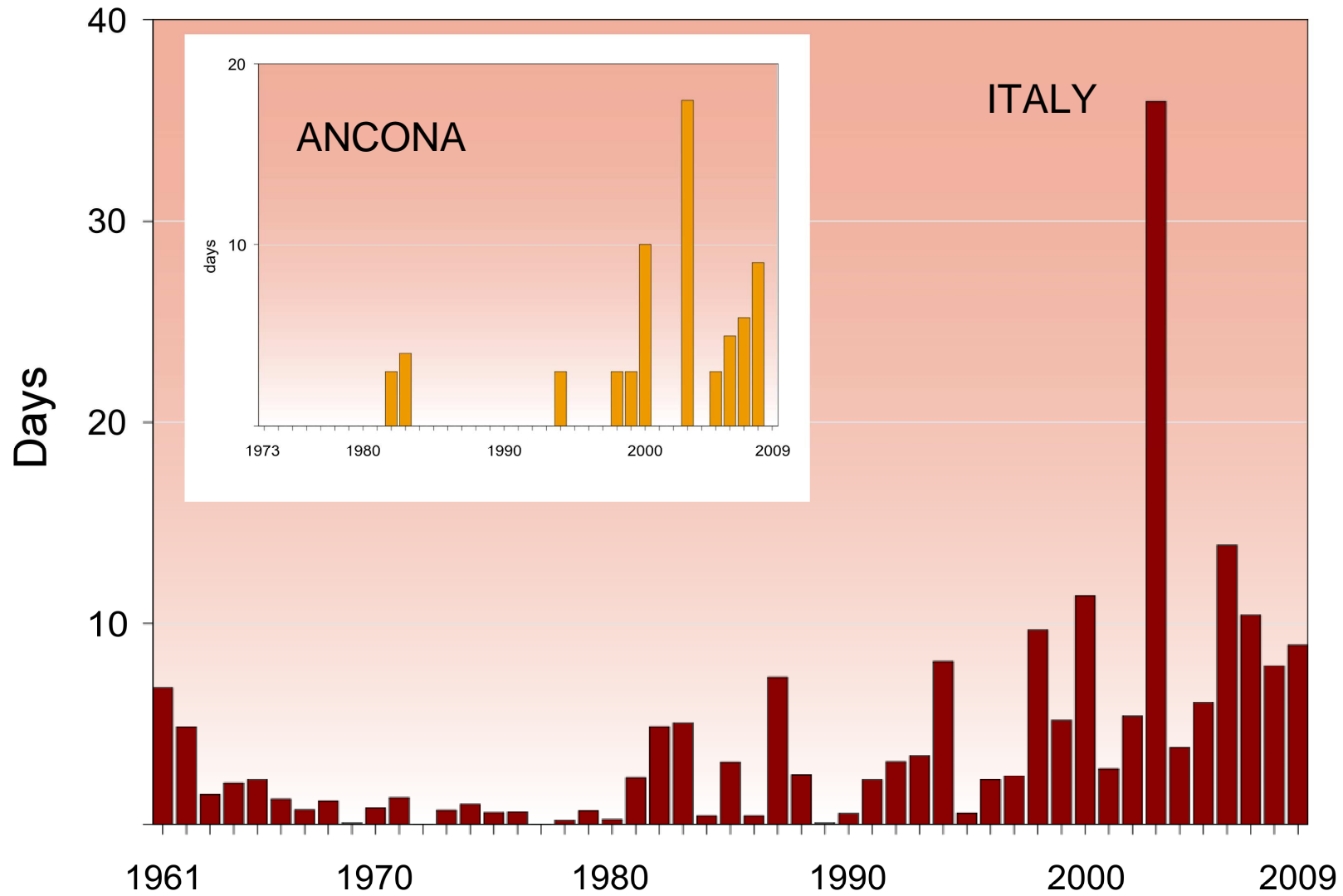
Which threshold? How long? No WMO standard definition

Here: maximum temperature exceeding the 95th percentile for at least three days (Kuglitsch *et al.*, 2010)

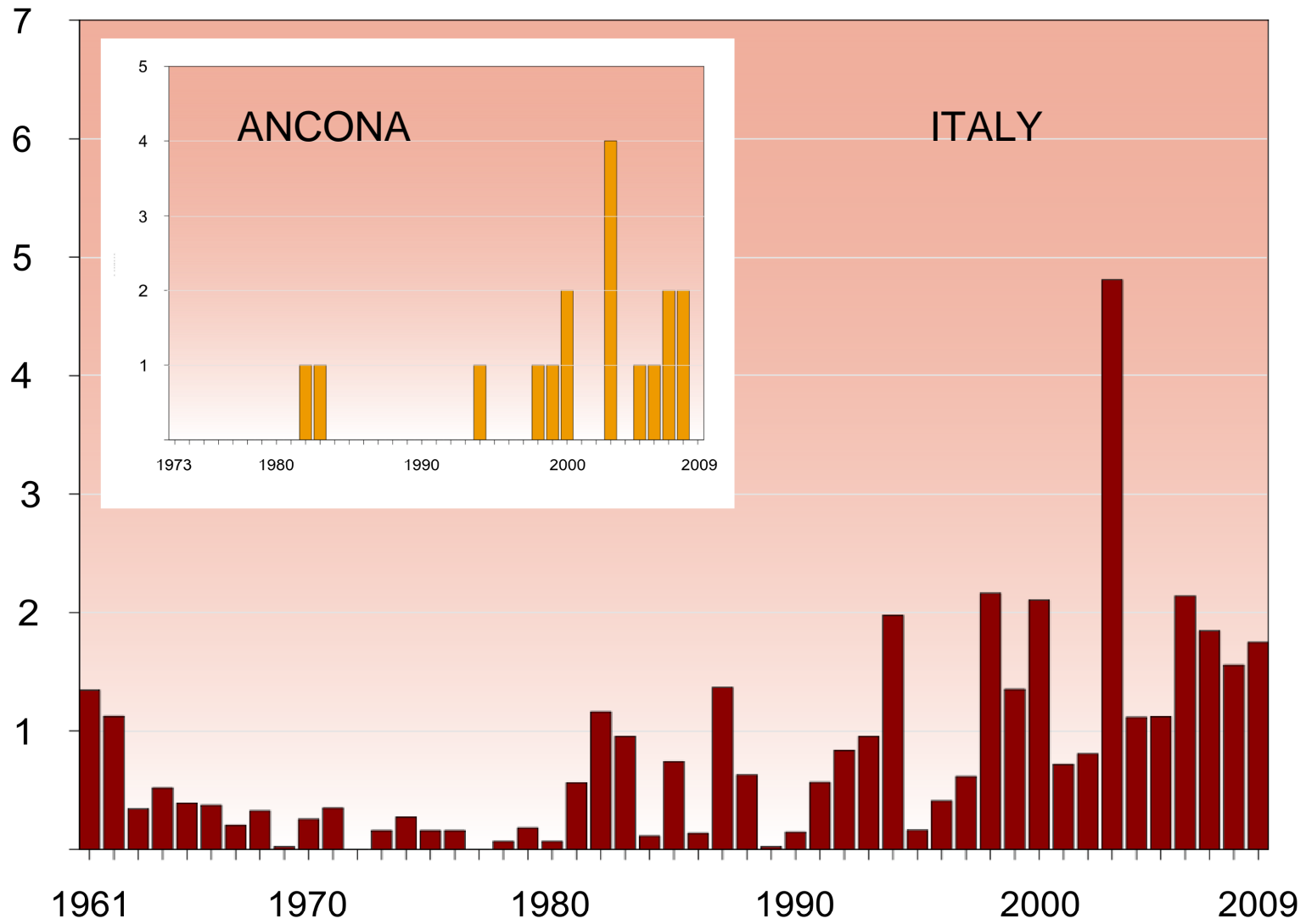
HWII: Heat Wave Hintensity Index



LWII: Length of the Heat Wave

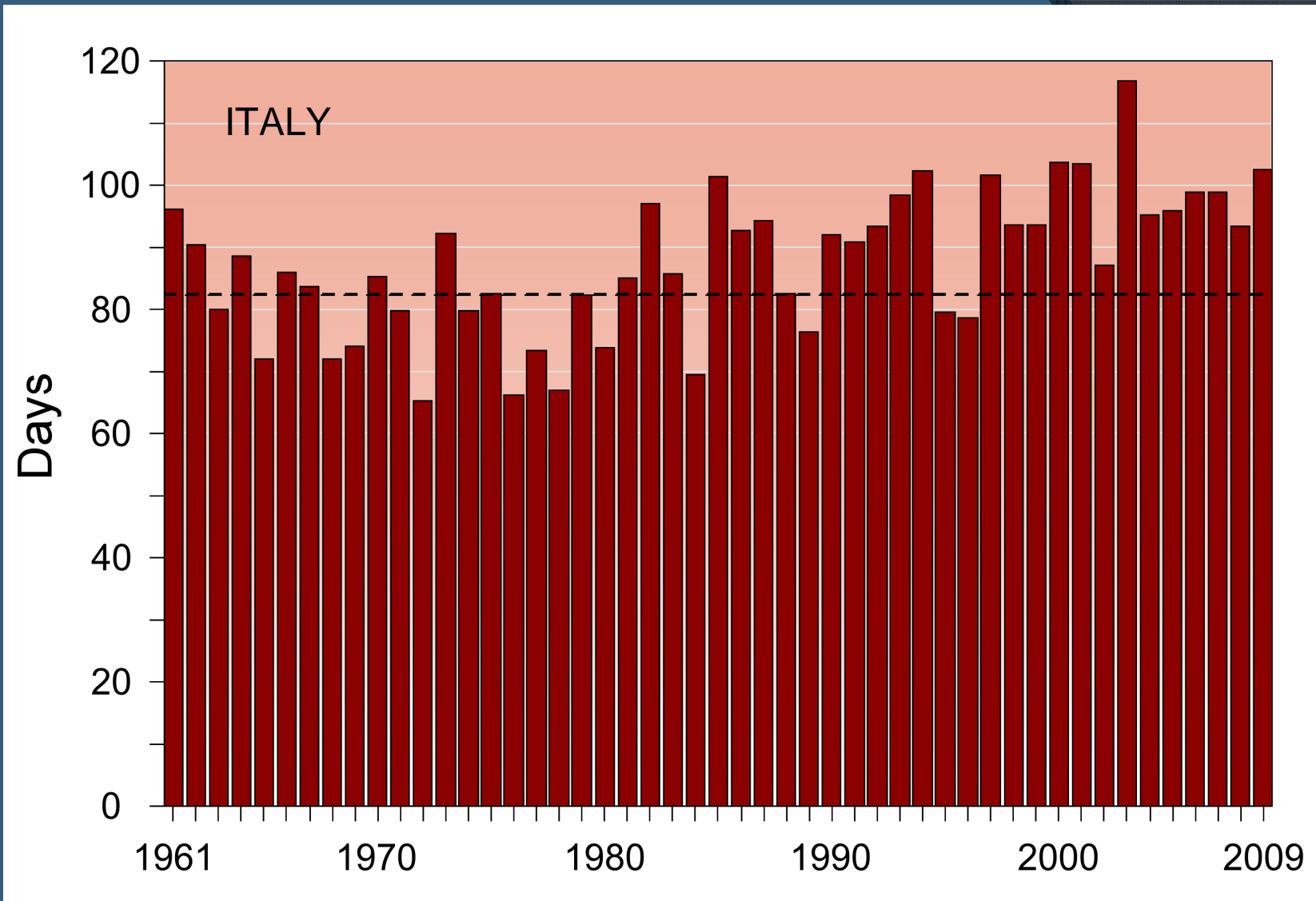


NWII: Number (frequency) of the Heat Waves



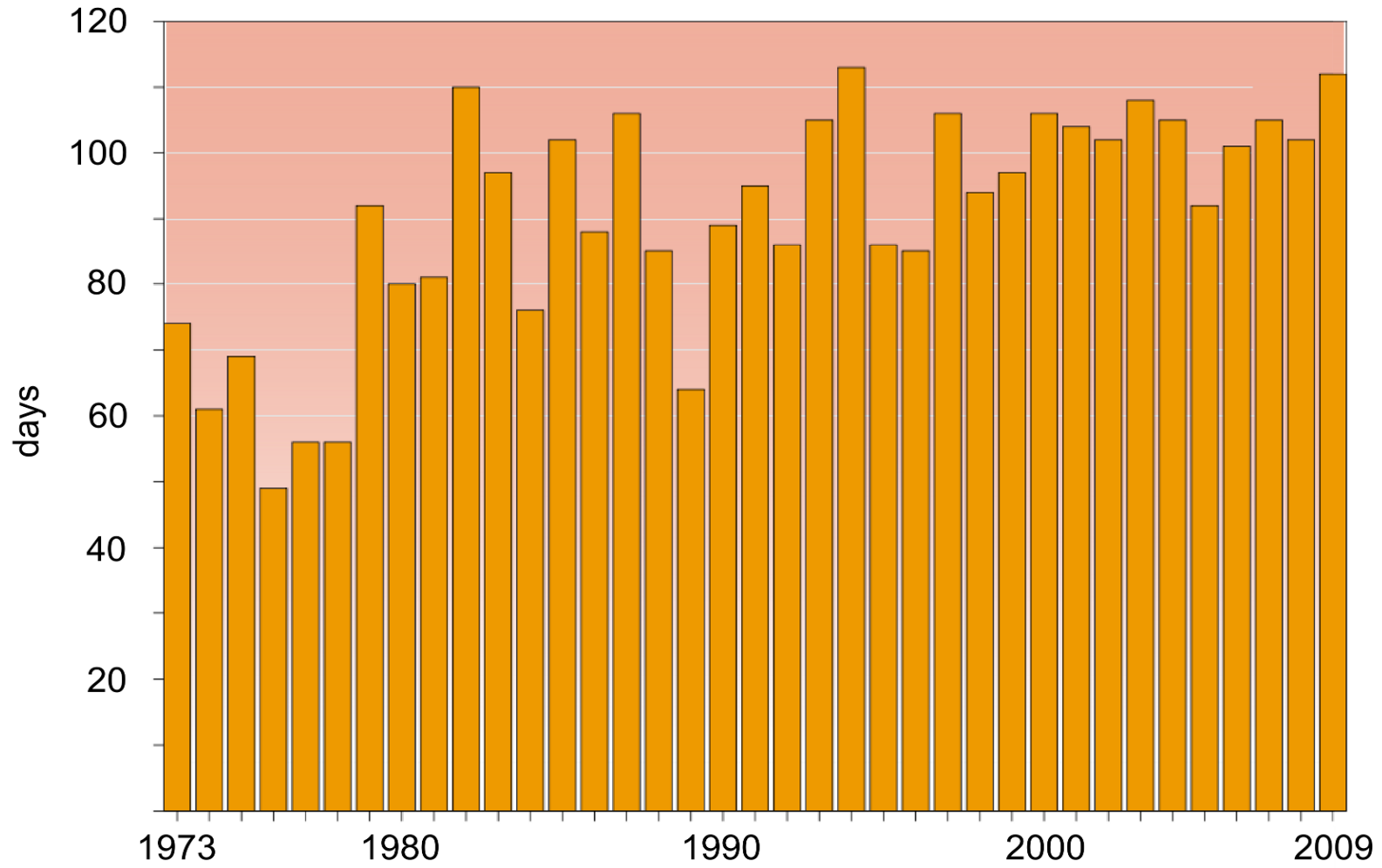
SUMMER DAYS

Days with maximum temperature greater than 25 °C



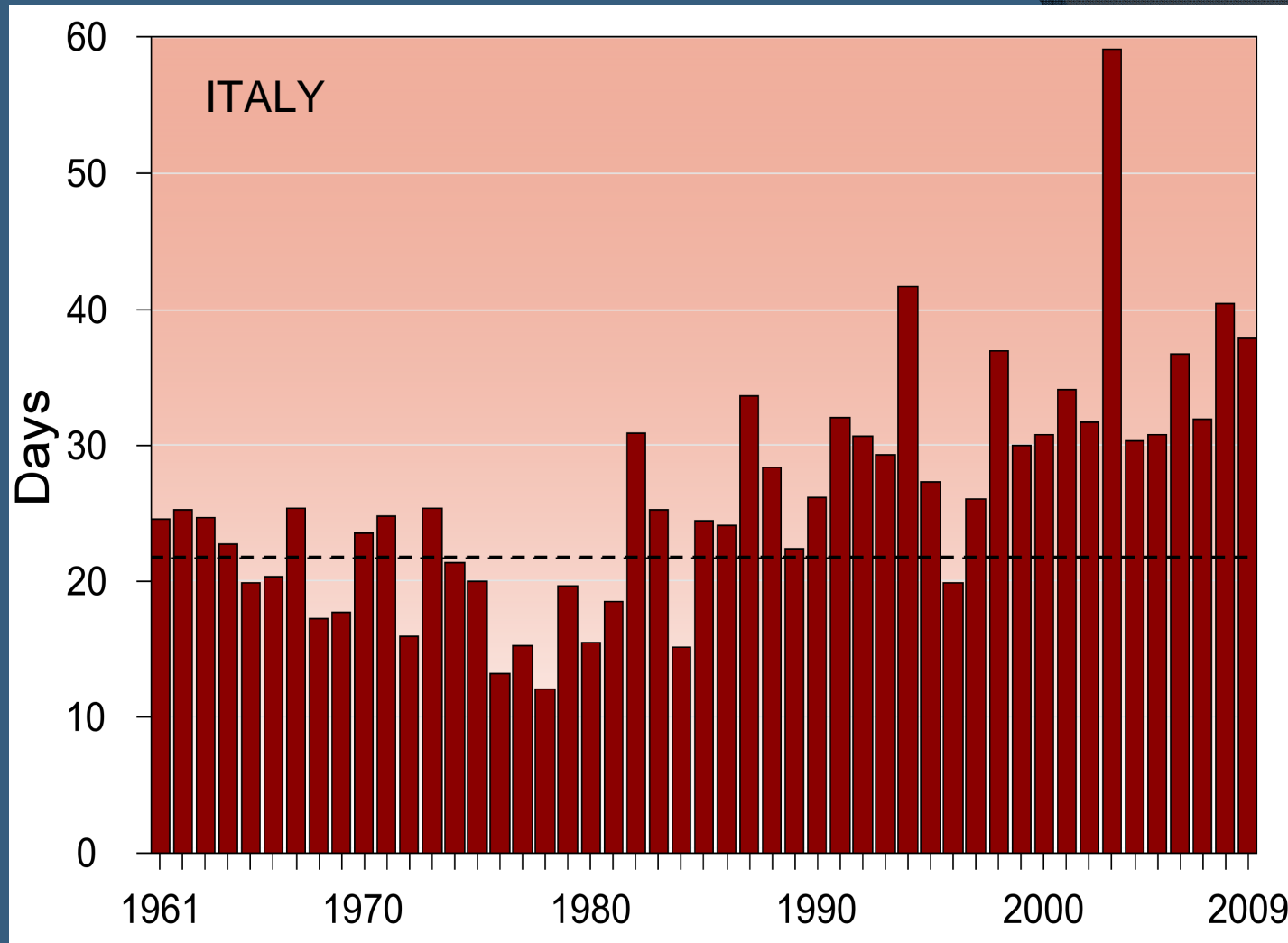
SUMMER DAYS

ANCONA



TROPICAL NIGHTS

Nights with a minimum temperature greater than 20 °C



Warm nights are known to strongly amplify health effects by inhibiting the recovery from the daytime heat and exacerbating the impact through sleep deprivation

TROPICAL NIGHTS

